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by Didier Garriguet

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Abstract

According to results from the 2004 Canadian Community Health Survey–Nutrition, Canadians get an average of 132 milligrams of vitamin C a day from food. About one adult in five has inadequate dietary intake of vitamin C. A third of Canadians take vitamin C supplements, which add 100 milligrams to total average daily intake. Supplement use lowers the overall percentage of adults with inadequate intake by 5 percentage points to 17%. Smokers, people who eat fruit and vegetables infrequently, and members of households with low income and low educational attainment tend to have relatively low vitamin C intake.

Keywords

ascorbic acid, diet, fruit, nutrition, vegetables

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Vitamin C is a powerful antioxidant that contributes to the formation and health of blood vessels, tendons, ligaments, bones, teeth and gums.¹ It helps the body absorb iron and recover from wounds and burns. Serious deficiency can lead to scurvy, which is now a rare condition in the Western world.

Fruit and vegetables are the main dietary sources of vitamin C, but it can also be taken as a supplement. In fact, vitamin C is taken more often than other supplements.²

This article provides an overview of vitamin C intake among Canadians and how levels are affected by supplement use.

According to the Institute of Medicine, the estimated average requirements for vitamin C range from 13 milligrams for toddlers aged 1 to 3 to 75 milligrams for adult men and 60 milligrams for adult women (Table 1). Because smokers have below-normal antioxidant levels and their bodies use vitamin C more quickly, their requirements are 35 milligrams higher than those of non-smokers. The recommended intake level maintains a near-maximum concentration of neutrophil (a type of leukocyte) in the blood, and minimizes the loss of vitamin

Table 1
Estimated average daily vitamin C requirements, by age group and sex

Age group	Milligrams per day ¹	
	Male	Female
1 to 3	13	13
4 to 8	22	22
9 to 13	39	39
14 to 18	63	56
19 or older	75	60

¹ 35 milligrams higher for smokers.

Note: Excludes pregnant and breastfeeding women.

Source: Reference 1.

C in the urine. The Institute of Medicine recommendations are not nearly as high as those of some other sources, which advocate intake as high as 400 or even 2,000 milligrams per day.³ This analysis, however, examines vitamin C intake in relation to the Institute of Medicine recommendations, which were set jointly by Canada and the United States and are used by Health Canada.⁴

Vitamin C from food

Three sources—fruit juice, fruit drinks and citrus fruits—accounted for 50% of the vitamin C that Canadians got from food in 2004; fruit juice alone made up 32% (Table 2).

Regardless of their age, sex, household income, level of education or province of residence, Canadians' average dietary intake of vitamin C was well above the Institute of Medicine recommendations. In 2004, Canadians averaged 132 milligrams of vitamin C a day from food alone (Table 3). Quebec residents, whose fruit and vegetable consumption is highest,² had the highest provincial dietary intake of vitamin C: a daily average of 144 milligrams.

High averages, however, hide the substantial percentages of various groups whose vitamin C intake from food left them below the recommended levels. When smokers' greater vitamin C requirements are factored in, 21% to 35% of men aged 19 or older had inadequate dietary intake; among women, the percentages ranged from 17% to 26%. Fewer than 10% of children and teens had inadequate dietary intake of vitamin C (Table 3).

Not surprisingly, a high percentage—46%—of people who reported that they ate fruit and vegetables infrequently (no more than three times a day) had inadequate dietary intake of vitamin C. The percentages were also significantly high among people in the lowest income (25%) and education (35%) households and among those who were inactive during their leisure time (30%). Partly because smokers' recommended intake is greater, over half (52%) of them had inadequate vitamin C intake from food. In fact, despite their greater requirements, smokers' average dietary intake of vitamin C was lower than that of non-smokers.

The people who took supplements containing vitamin C also tended to get more vitamin C from their diet than those who did not: a daily average of 142 milligrams, compared with 126 milligrams. Thus, based on diet alone,

Table 2

Main dietary sources of vitamin C, household population aged 1 or older, Canada excluding territories, 2004

Rank	Food	%	Percentage of dietary vitamin C intake	
			95% confidence interval	
			from	to
1	Fruit juice	31.8	30.8	32.9
2	Fruit drinks	10.5	9.9	11.2
3	Citrus fruits (orange, grapefruit, lemon, etc.)	7.0	6.6	7.4
4	Tomatoes	5.8	5.5	6.0
5	Broccoli	5.1	4.7	5.6
6	Red and green peppers	4.8	4.5	5.2
7	Potatoes	3.5	3.2	3.7
8	Melons (cantaloupe, honeydew melon, watermelon, etc.)	2.8	2.3	3.4
9	Strawberries	2.6	2.3	2.8
10	Lettuce and green leafy vegetables (spinach, mustard greens, etc.)	1.9	1.7	2.1
11	Other fruits (blueberries, dates, kiwis, fruit salad, dried fruit, etc.)	1.9	1.6	2.1
12	Other vegetables (cucumber, Brussels sprouts, beets, turnip, etc.)	1.8	1.6	2.0
13	Bananas	1.8	1.7	1.9
14	Tomato and vegetable juice	1.7	1.4	2.0
15	Potato chips	1.7	1.5	1.8

Source: 2004 Canadian Community Health Survey—Nutrition

those who did not take supplements were more likely than supplement consumers to have inadequate vitamin C intake (25% versus 17%) (data not shown).

Supplements

Just under a third (31%) of Canadians took supplements containing vitamin C in 2004 (Table 3). In general, the groups that had higher average dietary intake of vitamin C were also the most likely to take supplements—36% of people who ate fruit and vegetables more than six times a day did so, as did 38% of those with the highest household incomes, 34% of those who belonged to a household with at least one postsecondary graduate, 35% who were physically active, and 32% of non-smokers.

Quebec differed from the other provinces in that it had the highest dietary intake of vitamin C, but the lowest percentage of consumers of vitamin C supplements (Table 3).

Impact on intake

For the population as a whole, supplements provided 43% of vitamin C intake, twice as much as the main dietary source, fruit juice. And for the minority

of the population (31%) who were supplement consumers, the percentage was nearly 70%.

Supplement consumption raised Canadians' overall vitamin C intake by 100 milligrams to an average of 233 milligrams a day. Among supplement consumers, total daily intake averaged 463 milligrams.

Despite the substantial increase in average milligrams a day, the overall effect of supplements was relatively modest, reducing the percentage of the total population with inadequate vitamin C intake by just 5 percentage points. This is because more than two-thirds of Canadians did not take supplements, and those who did take them were likely to already have adequate dietary intake of vitamin C. Nonetheless, except among the age groups from 1 to 30, the reductions in inadequate vitamin C intake due to supplement consumption were significant (Table 3). The impact of supplement consumption was greater for smokers and for people who eat fruit and vegetables infrequently: almost a 10-percentage-point reduction.

As might be expected, few supplement consumers had inadequate vitamin C

Table 3
Vitamin C intake by supplement consumption and selected characteristics, household population aged 1 or older, Canada excluding territories, 2004

Characteristics	Dietary vitamin C intake				Percentage taking supplement containing vitamin C		Total vitamin C intake (dietary and supplements)			
	Average (milligrams)	Standard error	Inadequate ¹ (%)	Standard error	%	Standard error	Average (milligrams)	Standard error	Inadequate ¹ (%)	Standard error
Total	132	1	22.5	0.5	31.4	0.5	233	3	17.7	0.5
Age group and sex										
1 to 3	135	3	<3		36.2	1.6	169	5	<3	
4 to 8	144 ¹	3	<3		43.7 ¹	1.4	189 ¹	4	<3	
9 to 13										
Boys	166	5	<3		31.9 ¹	1.8	218 ¹	8	<3	
Girls	147	4	<3		30.4 ¹	1.8	203	7	<3	
14 to 18										
Boys	163 ¹	5	9.6 ¹	1.8	20.9 ¹	1.4	221	8	8.1 ¹	1.7
Girls	147	4	8.1 ¹	1.6	24.2 ¹	1.4	214	7	7.3 ¹	1.5
19 to 30										
Men	158 ¹	7	21.2 ¹	3.3	25.1	1.7	242 ¹	10	15.8 ¹	3.1
Women	132 ¹	5	17.2 ¹	3.0	29.2 ¹	1.7	215	9	16.1 ¹	2.5
31 to 50										
Men	128 ¹	4	31.8 ¹	2.7	24.2 ¹	1.5	214 ¹	9	26.1 ¹	2.5
Women	117 ¹	4	26.2 ¹	2.1	34.7 ¹	1.6	247 ¹	12	18.2	1.9
51 to 70										
Men	130	5	30.1 ¹	2.3	31.9 ¹	1.4	261 ¹	12	23.7 ¹	1.9
Women	121	3	19.7 ¹	1.8	37.4	1.5	271	11	15.1	1.6
71 or more										
Men	111 ¹	4	34.5 ¹	2.8	31.6 ¹	2.0	237	12	28.8 ¹	2.4
Women	107 ¹	3	22.8	1.9	38.1	1.6	254	11	17.1	1.7
Times per day fruit/vegetables consumed										
3 or less	87 ¹	2	46.2 ¹	1.4	26.8 ¹	0.9	167 ¹	5	36.7 ¹	1.2
3.01 to 5 ¹	136	2	15.7	0.7	32.5	0.7	240	4	11.8	0.6
More than 6	194 ¹	4	4.8 ¹	0.5	36.3 ¹	1.1	320 ¹	9	3.7 ¹	0.5
Household income quintile										
First (lowest)	125 ¹	3	25.0 ¹	1.3	25.5 ¹	1.1	201 ¹	7	21.2 ¹	1.2
Second	124 ¹	3	23.4	1.4	28.9 ¹	1.1	209 ¹	6	18.5 ¹	1.2
Third	133 ¹	3	21.7	1.3	32.1 ¹	1.3	236 ¹	8	17.5	1.2
Fourth	135	3	21.3	1.1	35.0	1.1	259	9	15.6	1.1
Fifth (highest) ²	143	3	19.8	1.2	37.6	1.3	265	8	14.5	1.1
Highest level of household education										
Less than secondary	102 ¹	2	35.2 ¹	1.8	24.1 ¹	1.2	185 ¹	6	29.0 ¹	1.6
Secondary graduation	117 ¹	4	27.9 ¹	1.8	25.8 ¹	1.2	196 ¹	7	23.5 ¹	1.7
Some postsecondary	125 ¹	4	24.3 ¹	1.9	29.7 ¹	1.6	214 ¹	9	19.0 ¹	1.9
Postsecondary graduation ³	139	2	19.1	0.6	33.7	0.6	247	4	14.7	0.6
Smoker (aged 12 or older)										
No ⁴	136	2	14.6	0.7	32.0	0.6	253	4	11.2	0.6
Yes	110 ¹	3	52.2 ¹	2.5	24.7 ¹	1.1	195 ¹	7	42.9 ¹	2.1
Level of physical activity (aged 12 or older)										
Active	152 ¹	3	14.9 ¹	1.3	34.5 ¹	1.2	284 ¹	9	12.5 ¹	1.2
Moderately active	139 ¹	3	16.4 ¹	1.6	31.9 ¹	1.1	257 ¹	8	11.7 ¹	1.5
Inactive ⁵	118	2	29.9	1.1	28.0	0.8	214	5	24.1	1.0
Province										
Newfoundland and Labrador	120 ¹	4	30.0 ¹	2.2	20.5 ¹	1.5	178 ¹	10	25.9 ¹	2.0
Prince Edward Island	107 ¹	4	29.0 ¹	2.2	28.1	1.9	198 ¹	11	23.7 ¹	2.0
Nova Scotia	109 ¹	3	27.2 ¹	2.2	28.1	2.0	191 ¹	10	21.1	2.1
New Brunswick	113 ¹	5	31.0 ¹	2.7	24.7 ¹	1.7	188 ¹	11	24.8 ¹	2.6
Quebec	144 ¹	3	18.3 ¹	1.2	21.6 ¹	1.1	202 ¹	6	15.6 ¹	1.1
Ontario	131	2	22.3	1.0	33.8 ¹	0.8	241 ¹	6	17.7	0.9
Manitoba	118 ¹	3	27.8 ¹	1.6	32.9	1.2	224	9	20.5 ¹	1.4
Saskatchewan	127	7	24.3	2.2	39.3 ¹	1.9	282 ¹	18	16.8	1.9
Alberta	125	4	25.2	1.7	39.0 ¹	1.4	247	11	17.3	1.5
British Columbia	134	3	21.0	1.5	37.5 ¹	1.4	267 ¹	10	15.0 ¹	1.3

¹ below estimated average requirement

² reference category; for provinces, reference category is Total

³ significantly different from estimate for reference category (p<0.05)

⁴ significantly different from estimate for preceding age group of same sex (p<0.05)

⁵ significantly different from estimate for females of same age (p<0.05)

⁶ use with caution (coefficient of variation 16.6% to 33.3%)

⁷ coefficient of variation more than 33.3%, but limits of confidence interval included within interval (0.0, 3.0)

⁸ not applicable

Notes: All averages that include supplement intake are significantly different from those for dietary intake only. Percentages with inadequate dietary and total intake are not significantly different for ages 1 to 13 and for women aged 14 to 30; in all other cases, differences are significant.

Source: 2004 Canadian Community Health Survey—Nutrition

The data

The 2004 Canadian Community Health Survey—Nutrition collected information about the food and nutrient intake of the household population at the national and provincial levels. Information about the use of vitamin and mineral supplements was also collected. The survey excluded members of the regular Canadian Forces; residents of the three territories, Indian reserves, institutions and some remote areas; and all residents (military and civilian) of Canadian Forces bases. Detailed descriptions of the survey design, sample and interview procedures are available in a published report.⁸

A total of 35,107 people responded to an initial 24-hour dietary recall, and a subsample of 10,786 took part in a second dietary recall three to ten days later. The response rates were 76.5% and 72.8%, respectively.

Canadians' intake of food and nutrients was estimated with a 24-hour dietary recall. To help respondents remember what and how much they ate and drank the previous day, interviewers used the automated multiple-pass method (AMPM),^{9,10} which consists of five steps:

- a quick list (respondents reported all foods and beverages consumed);
- questions about specific food categories and frequently forgotten foods;
- questions about the time and occasion of consumption;
- questions seeking more detail about the foods and beverages and the quantities consumed; and
- a final review.

Questions about vitamin and mineral supplements pertained to consumption frequency in the last 30 days. Respondents were asked the number of days that they had taken supplements and the average quantity consumed. More information about these derived variables is available in the survey documentation.⁸

The nutrient content of the food that respondents reported was derived from Health Canada's Canadian Nutrient File (Supplement 2001b).¹¹ The composition of supplements was taken from the Drug Product Database (DPD)¹² for September 2003 in the case of drug identification numbers listed at the time of collection, and for spring 2005 if the drug identification numbers were missing or incorrect.

This study examined data for 34,386 people aged 1 or older, 10,591 of whom responded to the second 24-hour dietary recall. Children younger than 1 year (288), pregnant (175) and nursing (92) women, breastfed children (104), and respondents with no dietary intake (16) or invalid dietary intake (45) were excluded from the analysis.

SIDE (Software for Intake Distribution Estimation)^{13,14} was used to determine the usual distribution, and in particular, the percentage of the population with inadequate vitamin C intake (below the estimated average requirement). To compensate for within-individual intake variability, the daily distribution of the intake of a nutrient was adjusted with the second dietary recall. Because the vitamin C requirements of children, teens, adults, males, females and smokers differ, intake is expressed in relation to the requirements of the group to which the respondent belongs. Hence, the percentage of the population with inadequate vitamin C intake is the proportion for which the ratio is less than 1.

The distribution of vitamin C intake that includes both dietary sources and supplements was determined by combining estimated intake from food alone for the respondents who do not take supplements and the total estimate (intake from food plus average daily intake from supplements) for respondents who take supplements. Details about the methods are available in an accompanying article.⁵

To account for the complex design of the Canadian Community Health Survey, the bootstrap method^{14,15} was used to estimate standard errors, coefficients of variation and confidence intervals. The statistical significance level was set at 0.05.

Fruit and vegetable consumption frequency is not based on the 24-hour dietary recall; it refers to the reported number of times per day that respondents ate fruit and vegetables, not the quantities that they consumed.

Household income is income from all sources in the previous 12 months. The ratio of total household income to the low-income cut-off for the relevant household size and community size was calculated for each household. The ratios were adjusted by dividing them by the highest ratio for all Canadian Community Health Survey respondents. The adjusted ratios were grouped into quintiles, the first quintile containing the lowest incomes, and the fifth, the highest.

Highest level of household education refers to the highest level of educational attainment of at least one household member.

Smoker refers to people who reported that they smoked daily or occasionally. *Level of physical activity* (inactive, moderately active, active) is based on average daily energy expenditure derived from the reported frequency and duration of all leisure-time physical activity in the three months before the interview and each activity's metabolic energy expenditure (non-leisure activity is not included). These two variables are not available for respondents younger than 12.

intake—2% overall, 5% among those who ate fruit and vegetables no more than three times a day, and 7% among smokers (Table 4). However, if the people who took supplements had not done so, based on their diet alone the percentages with inadequate intake would have been 17% overall, and 40% for smokers and infrequent consumers of fruit and vegetables.

Conclusion

More than 20% of Canadians do not get sufficient vitamin C from their diet. Roughly a third of the population takes vitamin C in the form of supplements. While supplements virtually eliminate inadequate intake among those who take them, the impact on the population as a whole is minimal. ■

Table 4
Percentage with inadequate vitamin C intake, by supplement consumption
and selected characteristics, household population aged 1 or older who take
vitamin C supplements, Canada excluding territories, 2004

Characteristics	Percentage with inadequate ¹ vitamin C intake based on:			
	Diet		Diet and supplements	
	%	Standard error	%	Standard error
Total	17.3	0.9	1.7	0.2
Age group and sex				
1 to 3	<3	—	<3	—
4 to 8	<3	—	<3	—
9 to 13				
Boys	<3	—	<3	—
Girls	<3	—	<3	—
14 to 18				
Boys	F	—	<3	—
Girls	F	—	2.1 ¹	0.6
19 to 30				
Men	19.0 ¹	5.4	3.7 ¹	1.2
Women	F	—	2.2 ¹	0.7
31 to 50				
Men	26.8 ¹	5.3	3.0 ¹	1.0
Women	25.4	3.5	2.3 ¹	0.6
51 to 70				
Men	23.6 ¹	4.6	2.0 ¹	0.6
Women	12.4 ¹	2.4	1.3 ¹	0.4
71 or more				
Men	23.7 ¹	4.8	F	—
Women	15.8	2.2	<3	—
Times per day fruit/vegetables consumed				
3 or less	40.1	3.0	4.6	0.7
3.01 to 5	13.5	1.1	1.2 ¹	0.2
More than 5	3.4 ¹	0.8	<3	0.1
Household income quintile				
First (lowest)	17.4	2.1	2.0 ¹	0.5
Second	18.3	2.3	1.9 ¹	0.4
Third	14.6	1.9	1.3 ¹	0.3
Fourth	18.0	1.8	1.3 ¹	0.3
Fifth (highest)	16.4	1.9	2.1 ¹	0.6
Highest level of household education				
Less than secondary	29.3	3.1	2.5 ¹	0.7
Secondary graduation	20.1	2.5	2.4 ¹	0.7
Some postsecondary	18.0 ¹	3.0	1.9 ¹	0.5
Postsecondary graduation	15.0	1.0	1.5	0.2
Smoker (aged 12 or older)				
No	11.8	1.2	1.0 ¹	0.2
Yes	44.2	6.3	7.3 ¹	1.2
Level of physical activity (aged 12 or older)				
Active	8.4 ¹	1.7	1.0 ¹	0.3
Moderately active	16.4	2.5	1.8 ¹	0.4
Inactive	23.8	2.0	3.2	0.5
Province				
Newfoundland and Labrador	19.8 ¹	4.1	F	—
Prince Edward Island	19.1 ¹	4.4	<3	—
Nova Scotia	23.8 ¹	4.1	<3	—
New Brunswick	27.0 ¹	5.1	F	—
Quebec	13.7	2.2	1.7 ¹	0.5
Ontario	16.1	1.6	1.5	0.2
Manitoba	24.8	3.0	2.2 ¹	0.5
Saskatchewan	19.9 ¹	3.3	2.0 ¹	0.6
Alberta	21.6	2.7	2.0 ¹	0.6
British Columbia	17.2	2.2	1.5 ¹	0.4

¹ below estimated average requirement

² use with caution (coefficient of variation 16.6% to 33.3%)

F too unreliable to be published (coefficient of variation more than 33.3%)

<3 coefficient of variation more than 33.3% but limits of confidence interval included within interval (0.0, 3.0)

— not applicable

Note: Estimates of percentage with inadequate dietary and total intake are not significantly different for ages 1 to 18 and for women aged 19 to 30. In all other cases, differences are significant.

Source: 2004 Canadian Community Health Survey—Nutrition

References

1. Institute of Medicine. *Dietary Reference Intake for Vitamin C, Vitamin E, Selenium and Carotenoids*. Washington DC: National Academy Press, 2000.
2. Garriguet D. Combining nutrient intake from food and from vitamin and mineral supplements. *Health Reports* (Statistics Canada, Catalogue 82-003) 2010; 21 (forthcoming).
3. Hedron J. James Pauling Institute Micronutrient Information Center: vitamin C, 2008. Available at: <http://pn.oregonstate.edu/info/center/vitamins/vitaminC>. Accessed May 7, 2009.
4. Health Canada. *Canadian Community Health Survey: Cycle 2.2, Nutrition (2004) - A Guide to Accessing and Interpreting the Data* (Catalogue H164-20/2006L). Ottawa: Health Canada, 2006.
5. Garriguet D. *Overview of Canadians' Eating Habits, Nutrition Findings from the Canadian Community Health Survey* (Statistics Canada, 82-620-MIE2006002) 2006. Available at: <http://www.statcan.gc.ca/pub/82-620-m/82-620-m2006002-eng.htm>.
6. Béland Y, Dale V, Dufour J, Hamel M. The Canadian Community Health Survey: Building on the success from the past. *Proceedings of the American Statistical Association Joint Statistical Meeting, Section on Survey Research Methods, August 2005*. Minneapolis: American Statistical Association, 2005.
7. Moshfegh AJ, Borriud L, Perloff B, et al. Improved method for the 24-hour dietary recall for use in national surveys. *The FASEB Journal: Official Publication of The Federation of American Societies for Experimental Biology* 1999; 13: A603 (Abstract).
8. Moshfegh AJ, Raper N, Ingwersen L, et al. An improved approach to 24-hour dietary recall methodology. *Annals of Nutrition and Metabolism* 2001; 45(suppl): 156 (abstract).
9. Statistics Canada. *Canadian Community Health Survey (CCHS): Cycle 2.2, Nutrition: General Health Component Including Vitamin and Mineral Supplements, and 24-hour Dietary Recall Component*. Derived variables documentation, 2008.
10. Health Canada. 2005. *Canadian Nutrient File, 2005 Version*. Available at: http://www.hc-sc.gc.ca/fnan/nutrition/fiche-nutri-data/index_e.html.
11. Health Canada. *Drug Product Database*. Available at: <http://www.hc-sc.gc.ca/cdhp/mps/prodpharma/databasdon/index-eng.php>. Accessed January 26, 2009.
12. Nusser SM, Carquary AJ, Dossd KW, et al. A semiparametric transformation approach to estimating usual daily intake distributions. *Journal of the American Statistical Association* 1996; 91(436): 1440-9.
13. Novenario MJ. *User's Guide to SIEDE, A*. August 1996. Available at: <http://www.card.iastate.edu/publications/DBS/PDFfiles/96tr32.pdf>. Accessed September 12, 2005.
14. Rao JNK, Wu CFJ, Yue K. Some recent work on resampling methods for complex surveys. *Survey Methodology* (Statistics Canada, Catalogue 12-001) 1992; 18(2): 209-17.
15. Rust KF, Rao JNK. Variance estimation for complex surveys using replication techniques. *Statistical Methods in Medical Research* 1996; 5: 281-310.
16. Yeo D, Mantel H, et TP, Liu TP. Bootstrap Variance Estimation for the National Population Health Survey. *Proceedings of the Annual Meeting of the American Statistical Association, Survey Research Methods Section*. American Statistical Association: Baltimore, August 1999.

